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The Elusive Promise of Social-Ecological Approaches to Rangeland Management

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Abstract

Resilience-based frameworks for social-ecological systems (SES) are prominent in contemporary scientific literatures, but critics suggest these approaches may promise more than they deliver. A fundamental premise underlying the SES approach is that, because of the scope of human activities worldwide, we cannot separate ecological and human elements of nature when tackling our biggest challenges. Proponents argue that managers should not seek optimal solutions, but instead build capacity to adapt and transform systems to thrive within unpredicted or novel ecological states. If the range profession is to take advantage of resilience ideas, we need better tools and concepts for understanding interconnected systems. SES research and management strategies will pose practical difficulties, most notably finding ways to bridge differences between the methods of social and natural sciences. Also needed are institutions that involve scientists, managers, and stakeholders in analysis and informed governance, thereby addressing a key tenet of "resilience thinking" while accounting for the "wicked" nature of problems that, like many facing rangeland managers today, do not have a single best solution but only more or less feasible responses. In hopes of guiding managers toward more feasible options, I offer a model of rangeland social-ecological systems describing how management choices are influenced by, and may affect, human and natural systems at local and regional-to-global scales through both top-down and bottom-up processes.

Resumen

Los sistemas socio-ecológicos basados en modelos de resilencia (SES) son destacados en la literatura científica actual, pero los críticos sugieren que estos enfoques podrían prometer mas de los que entregan. La premisa elemental sobre el enfoque SES es que debido a el enfoque de las actividades del humano en todo el mundo, no podemos separar elementos naturales ecológicos y humanos cuando abordamos nuestros más grandes retos. Proponentes argumentan que los manejadores no deberían buscar soluciones óptimas y en lugar de estas construir la capacidades para adaptar y transformar sistemas que conduzcan a estados ecológicos nuevos o no predecibles. Si la profesión de pastizalero es tomar ventaja de las ideas de resilencia, necesitamos mejores herramientas y conceptos para entender los sistemas interconectados. Las investigaciones y manejo de estrategias para SES debe tener dificultades prácticas, y más importante encontrar los caminos para reducir las diferencias entre los métodos de las ciencias sociales y naturales. También se necesitan instituciones que involucren científicos, manejadores y propietarios en el análisis y informe de gobierno, de ese modo direccionando a clave de "pensamiento resilente" mientras se considera el perverso naturaleza de los problemas como los que hoy en día enfrentan los manejadores de pastizales, no hay una solución buena y simple pero solo respuestas más o menos posibles. Con el fin de guiar a los manejadores hacia opciones más posibles ofrezco un modelo de sistema socio-ecológico para pastizales describiendo como opciones de manejo son influenciadas por y podrían afectar sistemas humanos y naturales de nivel local y regional a escala global a través de ambos procesos de arriba hacia abajo y de abajo hacia arriba.

Key Words: adaptive management, complex problems, coupled natural-human systems, human dimensions of range management, interdisciplinary, wicked problems

INTRODUCTION

Resilience-based and "coupled natural-human systems" frameworks have become prominent in the literatures of environmental and natural resource management (e.g., Grimm et al. 2000; Ostrom 2009). It has been suggested, however, that these approaches may promise more than they deliver. Skeptics have suggested that social-ecological systems (SES) approaches lack the conceptual clarity needed to be practical for management of complex linked systems (Brand and Jax 2007), and that their application has been limited to "neat" systems where humans and their resources are treated as subsystems with simple and relatively clear flows (Anderies et al. 2004; Alessa et al. 2009). As SES frameworks are increasingly applied to rangelands (e.g., Janssen et al. 2000; Fox et al. 2009; Walker et al. 2009a), it will be important to assess whether they offer practical tools for managers or are merely another faddish academic pursuit. In this paper I discuss key aspects of SES research and practical difficulties of incorporating social and ecological science frameworks into analyses of coupled systems, and then I offer ideas about how to address those difficulties. The fundamental questions I hope to illuminate are 1) can social-ecological research lead to improvement in our capacity to sustain rangelands and 2) how might we enhance the probability that these improvements will be realized?

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Key Concepts in SES Research

Coupled Human and Natural Systems. The basic argument for studying rangelands (or any environment) as coupled natural and human systems has been offered in many contexts, but may be most easily seen in the work of the Resilience Alliance, a research network comprising scientists and practitioners from numerous disciplines, nations, and academic and government institutions who collaborate to explore SES dynamics. In a paper coauthored by many of the Alliance's most prominent scientists, Folke et al. (2010) argue that because of the rapid acceleration and expanding scope of human activities worldwide, it is "difficult and even irrational to separate the ecological and social and to try to explain them independently, even for analytical purposes." Yet although global-scale impacts may provide a justification for coupled-systems studies, global-scale issues are the most intractable, not only because of their immense complexity but also because we lack governance structures to effectively manage or even communicate about them (Walker et al. 2009b). Thus for practical reasons, almost all management occurs at smaller scales.

Does the same argument about inseparability apply at those smaller scales? It depends on what one hopes to achieve. Certainly most research has been, and will continue to be, focused on the properties of specific elements within one type of system component: biological, physical, economic, or social. However, when the object of study is the whole system, or when the purpose of research is to change management practices in a way likely to affect more than one type of component, failure to consider both human and ecological components often leads to a failure of management. The past few decades have seen many examples of how range management based on our best ecological understanding has generated controversy over issues as disparate as feral horses, fuel hazard reduction, and native plant restoration to the extent that recommended actions cannot be implemented.

The idea that social systems affect rangeland ecosystems is not new. Nearly a half-century ago Stoddart (1965) warned that the future of public land grazing would depend not only on better science but also on an improved understanding of the changing demands of citizens. Yet it wasn't until the 1990s that analyses of human systems regularly found their way onto the pages of range management journals. Those studies were aimed toward describing and influencing human beliefs and behaviors, exploring what humans thought about or demanded from rangelands (Brunson and Steel 1996), how those demands were changing (Kennedy et al. 1995), or how people could be convinced to support or make greater use of ecologically justifiable rangeland uses and practices (Huntsinger and Hopkinson 1996; Kreuter et al. 2001). Rarely, however, did they explore how social and ecological systems are interdependent.

One exception was the work of the Sustainable Rangelands Roundtable (SRR), a collaboration launched in 2001 among range professionals from numerous agencies, organizations, and universities to identify and assess potential biological, physical, economic, social, and institutional indicators for monitoring the sustainability of rangelands at a national scale (Rowe et al. 2002). Although SRR's underlying assumption had always been that sustainability assessment must consider socioeconomic as well as natural system factors, the indicators initially were treated as a bundle of important but discrete factors that could be measured independently (Mitchell et al. 2003). Subsequently, participants explored how connections between natural and human-system factors might influence changes in rangeland conditions over time, building a two-tiered model (Fox et al. 2009) that emphasized fluctuation in capital stocks and resource flows as the locus of connection.

Meanwhile, agencies' adoption of an ecosystem management paradigm for public rangelands and forests implied acceptance of the idea that humans are part of ecosystems (Christensen et al. 1996), although this remained a topic for debate. Endter-Wada et al. (1998) argued for two roles of social scientists in ecosystem management: 1) understanding participation by, or influence of, humans in decision making and 2) integrating human concerns into the science of understanding ecological systems. The authors specifically criticized a tendency of natural resource scientists to view human activities solely as environmental stressors or as "constraints" on implementation of management strategies. Lately this idea has been echoed by prominent scientists who hold that "social-ecological systems . . . are neither humans embedded in an ecological system nor ecosystems embedded in human systems . . . but rather a different thing altogether" (Walker et al. 2006). That view has gained ascendancy among ecological scientists (Berkes 2004), in part because it parallels a shift from a more reductionist view of ecology to a systems conceptualization (Levin 1999; Gunderson and Holling 2002). Yet agreement on such a broad conceptual plane is just a first step; adoption of a set of theoretical, methodological, and practical concepts has proven more elusive.

Resilience and "Resilience Thinking." The conceptual/theoretical framework most commonly employed in SES research comes from the work of the resilience theorists. As originally described by Holling (1973), resilience was a measure of a system's ability to "absorb changes of state variables, driving variables, and parameters and still persist" (p. 17). That definition since has evolved to the one presented by Walker et al. (2006): the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity. This version reflects contemporary ideas regarding the defining role of disturbance in ecosystems and with nonequilibrium models of succession (Westoby et al. 1989). Accordingly, social-ecological resilience is described as "the capacity of linked social-ecological systems to absorb recurrent disturbances . . . so as to retain essential structures, processes, and feedbacks" (Adger et al. 2005, p. 347).

Not all ecologists accept the resilience view in its entirety. A recent study found that although ecologists generally concur with nonequilibrium models of system dynamics, divergent viewpoints remain about the attributes of disturbance that guide environmental change, the predictability of successional states after disturbance, and the utility of focusing management on higher levels of organization (e.g., from species to ecosystems) (Moore et al. 2009). We don't know whether our inability to anticipate system responses to disturbance reflects the systems' inherent unpredictability or simply inadequate science. Even so, either explanation supports the idea that management must be adaptive, informed more by iterative learning than generalizations about nature (Tompkins and

Adger 2004). Resilience theorists suggest that a traditional focus on efficiency and optimization in environmental problem solving has been counterproductive because optimal solutions are designed for stable states that may not exist after the next disturbance. They argue instead for the use of "resilience thinking" (Walker and Salt 2006), i.e., science and management aimed at reducing SES vulnerability to shocks by 1) focusing on transformative processes rather than stable states, 2) maintaining diversity and redundancy of system components, 3) improving information flow to detect thresholds before they're crossed, and 4) building social networks among scientists and stakeholders who can collaboratively influence change in response to local conditions and processes.

Critics of the resilience literature note that it is strong on the *why* but short on the *how*. As yet there exists no concise definition of resilience thinking. Research is dominated by case studies, a methodology that accounts for the fundamental uniqueness of each situation but does little to foster the sorts of generalizations upon which science has traditionally been built. Brand and Jax (2007) argue that, although resilience in ecology is a descriptive concept that can guide research and theory development, when viewed at the level of SES it serves more as a "boundary object" that aids communication across disciplinary boundaries by creating a shared vocabulary, even though specific understandings of meaning within those disciplines may differ. The authors warn that boundary objects can be a hindrance to scientific progress because of their imprecision. Reflecting what appears to be a fundamental distrust of social science, they argue for a "division of labor" where research focuses on ecological resilience, which offers "a clear, well defined and specified concept that provides the basis for operationalization and application," whereas social-ecological resilience is acknowledged as a vague and malleable concept that "has been reduced to a listing of any societal objectives that agents happen to think important."

Barriers to Development of Useful SES Frameworks

The Brand and Jax (2007) argument reflects not only skepticism about the value of resilience as a concept that can guide management, but also about the value of cross-disciplinary research involving both social and ecological scientists. Indeed, these scientists may approach their work very differently, but the extent to which those differences impede progress depends on our expectations about how research must be conducted, as well as about the nature of the management solutions that will be implemented.

Differences Across Disciplines. An attraction of the term *resilience* for SES research is that its use is not limited to ecology. In everyday language we speak of resilient individuals who have coped with stress or adversity. Resilience is a desirable trait in contemporary culture, as in the common phrase, "what doesn't kill me makes me stronger." Yet resilience in a psychological sense is not quite the same thing as resilience in an ecological sense. Adger (2000) defined social resilience as "the ability of groups or communities to cope with external stress and disturbances as a result of social, political, and environmental change" (p. 347). Although this definition is similar to the one used for ecological systems, Adger notes that equating the two "assumes that there are no essential differences in behavior or structure between socialized institutions and ecological systems. This is clearly contested in the social sciences" (p. 358). Institutions, for example, can transform themselves in direct response to repeated stressors; ecosystems, while self-organizing, are not volitional. Thus he suggests the resilience concept offers a bridge between social and ecological theories rather than a concept held in common.

Scientists who focus on SES dynamics have called for a new integrative ecology that explicitly incorporates human decisions, cultural institutions, and economic systems (Redman et al. 2004). Yet efforts to articulate social and ecological thinking have been impeded by fundamental methodological differences. For most of its history, range science has been dominated by an experimental paradigm in which analysis of variance was the statistical tool of choice; for most studies of human systems, experiments are infeasible and correlational approaches have dominated. Scoones (1999) observed that social science analysis remained "attached to a static, equilibrial view of ecology, despite the concerted challenges to such a view within ecology over many years" (p. 483). Conversely the idea of "ecosystem services" was quickly embraced by social scientists and some ecologists for its metaphorical elegance, but efforts to operationalize it have been slowed by both philosophical (McCauley 2006) and methodological issues (Farber et al. 2002). Efforts toward building an integrative social-ecological science may be enhanced by the trend in science toward large, interdisciplinary studies that facilitate exchange of ideas among social and natural scientists (Porter and Rafols 2009), as well as by statistical advances including the use of social data in ordination analyses that long have been a tool for ecologists (e.g., Ihde et al. 2011), refinement of Bayesian inference tools (Ellison 1996), and development by ecologists of structural equation models that have more typically been a social science tool (Grace et al. 2010).

Complexity and Wickedness. Boyd and Svejcar (2009) have suggested that rangeland science has been best at solving "simple" problems, where input variables and the relationships between them are essentially constant. In such situations, outcomes are predictable and general management rules can be devised. However, they argue, most of the challenges facing range managers today are "complex" problems in which the input variables are not constant and/or the relationships vary across space or time. Echoing Walker and Salt's (2006) critique of optimization, they suggest that general management rules are inadequate for such problems and may actually make matters worse. For the most part Boyd and Svejcar (2009) focus on ecological systems; if human system components are added to the puzzle the level of problem can escalate from "complex" to what Allen and Gould (1986) called "wicked." Complex problems do have solutions, though those solutions depend on spatial or temporal context. Wicked problems have no single formulation, and "best" outcomes are dependent on societal values, goals, or preferences. In such cases there are no right answers, only more or less useful ones. Ludwig (2001) argued that species conservation and climate change, among others, constitute wicked problems for which "there are no experts ... nor can there be" (p. 763). He concluded that for such problems scientists must share their advisory and decision-making roles with stakeholders on an equal footing. Thus he arrived by a different route at the same conclusion as resilience thinking proponents, who argue for participatory governance structures accountable to both citizens and higher authorities (Lebel et al. 2006).

AN SES MODEL FOR RANGELANDS

If SES problems are fundamentally "wicked," then it is easy to conclude that SES research cannot lead to management solutions. In one sense this is a valid point: Scientific analysis within an SES framework likely will never reveal universally applicable rules or guidelines. However, if resilience thinking requires that scientists and stakeholders collaboratively develop strategies that improve the system's capacity to adapt and transform itself in response to change (Walker et al. 2006), then SES research can provide vital information to guide those collaborative efforts. Boyd and Svejcar (2009) argue that rangeland scientists need to match their expectations with current challenges, e.g., by helping to define an acceptable range of conditions rather than prescribing management for an optimal "desired" condition. To do this well, SES researchers must be able to describe interconnections between multiple elements of coupled human and natural systems, and to predict which of those elements are most likely to be affected (and in what ways) by different types of ecological or societal shock. As a tool for furthering discussion, I offer a conceptual model of how rangeland ecosystems and human systems are linked (Fig. 1), based on observations from my own lab's SES research in northwestern and intermountain rangelands, as well as a review of recent literature. My hope is that it will be useful for assessing social and ecological influences and/or effects of decision alternatives, and thus can serve as a companion to other process models such as that of Collins et al. (2011), whose model offers a framework for long-term SES research, and Fox et al. (2009), who sought to inform assessments of overall change in US rangeland condition over time.

The model, adapted and expanded from one developed by Grimm et al. (2000) for urban ecosystems, is centered on the role of intentional actions (e.g., land-use decisions) to influence the capacity of ecosystems to provide goods and services. To achieve desired results, rangeland managers attempt to create a mix of ecosystem patterns and processes from among a range of possible combinations shaped by coarse-scale physical influences such as climate, soils, and topography. Thus decisions are governed by both ecological (what the land is capable of producing) and societal considerations (what people want from the land). The range of decisions and ecosystem attributes is defined by coarse-scale factors whereas fine-scale influences define variability within that range. For example, many land-use decisions concerning grazing on western US rangelands reflect the land's capacity to produce palatable forage plants, as well as policies designed to meet societal demands for meat products and rural economic opportunity. The same decisions are not applied in northwest forests, despite equally strong need to support rural economies, because climate and other factors create conditions that favor large trees over grasses.

We are now learning that those patterns and processes are affected not only by management and relatively stable ecological conditions, but also by bottom-up and top-down drivers. At regional to global scales, climate change is expected to affect the land's capacity to provide ecosystem services (Chambers and Pellant 2008). At the same time, non-native annual grass invasion has shaped a pattern of larger and more numerous wildfires in many ecosystems worldwide (Brooks et al. 2004). These drivers influence land-use decisions directly, as when restoration activities are initiated, and also by affecting the land's productive capacity. Feedbacks exist between local changes in ecological condition and ecosystem pattern and process, and between fine- and coarse-scale ecological influences, independent of any human action.

On the human side of the system, land-use decisions are shaped not only by top-down policies but also by what people

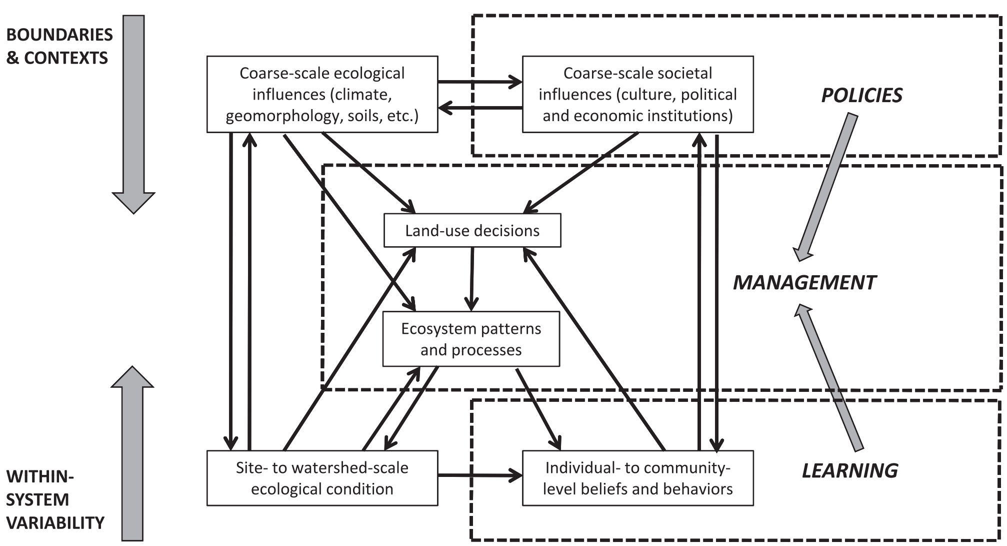

Figure 1. Conceptual multiscalar model of rangeland social-ecological systems, designed to guide assessment of effects of decision alternatives. Ecosystem patterns and processes are viewed as a consequence of land-use decisions, governed by top-down and bottom-up ecological and societal processes. The range of possible decisions and ecosystem attributes is bounded by coarse-scale factors while variability within that range is defined by fine-scale influences. Management to enhance SES resilience can incorporate policies intended to transform the overall decision space, and learning opportunities (e.g., monitoring, local ecological knowledge) to understand and adapt to local-scale variability.

learn from previous land-use decisions. As scientists, managers, and stakeholders observe the consequences of their decisions for ecosystems and for human well-being, their beliefs about land use can be altered. These changes can lead to new land-use decisions or to new policies. Policies can also change in response to coarse-scale ecological phenomena independent of local learning, e.g., federal agencies' recent emphasis on climate change is occupying managers' attention even though many field managers don't recognize climate change is occurring (Whitcomb 2011). Some of the most significant challenges faced by rangeland managers today occur when discrepancies arise between fine- and coarse-scale societal processes. For example, Shindler et al. (2011) found that rural and urban residents in the Great Basin hold divergent views about threats to rangelands, with rural concerns focused on changes in ecological processes while urban views emphasize real or imagined human mismanagement. Because urban citizens greatly outnumber rural residents in the region, policies may not reflect learning that occurs at local scales. This is one reason why resilience frameworks call for governance structures that can bring together both rural residents and urban stakeholders in forums where they can share ideas, values, and present evidence to back their beliefs.

A conceptual framework such as this can help scientists and others identify the categories of phenomena that should be considered in SES research. Some of these interconnections are well known to rangeland scientists; others are just beginning to appear in the literature. An interesting case study is offered by Morris et al. (2011), who found that contemporary patterns of non-native grass and forb invasion in northwestern Utah are legacies of plowing on dryland wheat farms in the early 20th century. Farms were established to take advantage of economic conditions arising from the outbreak of war in Europe, as well as policies rooted in a Jeffersonian vision of a nation of farmer-settlers (coarse-scale societal influences). Although the land at first seemed able to support dry farming, distance from larger settlements and an inhospitable climate led most homesteaders to abandon their farms within a few years. Even today, however, soils that were plowed and seeded with small grains have been altered in ways that can support fewer native plants and are more susceptible to invasion than even the surrounding landscape. Thus present-day ecological pattern and process arise from interactions among coarse-scale societal and ecological influences, as well as local-scale soil conditions and the choices of homesteaders who learned to distrust the agricultural science of the day. Building resilience in such systems requires an understanding not only of ecologically based invasive plant management (James et al. 2010), but also of the human-system influences that shape conditions on the land today.

As the above example suggests, SES approaches show promise for improved understanding of some of our most vexing rangeland science and management problems. But understanding can take us only so far. To fulfill that promise, SES research must also lead to tools for solving complex problems and achieving more useful answers to wicked ones. In the case of dryland field restoration, understanding the effect on vegetation pattern is only a first step; solutions will come when managers not only can predict where land-use legacies affect those patterns, but also know how to choose species and restoration treatments for reclaimed dry farms and to gauge the social consequences of those choices. Identifying explicit cross-system linkages in rangeland social-ecological systems, whether using the model described here or a different one (e.g., Walker et al. 2009), can be useful in directing researchers' attention to previously underappreciated aspects of difficult problems. To operationalize those linkages we will need to address challenges related to scale disparity and analytical approach, but even to reach that new level of challenge would represent a step forward from our current capacity.

MANAGEMENT IMPLICATIONS

Rangeland management has never been just about the land itself. From the beginning of the profession, managers have sought to maintain a relationship between rangelands and the people who hoped to benefit from the land, and to do it in such a way that those benefits were realized while the land retained its capacity to provide what society valued. In recent decades the societal side of that relationship often has seemed even more intractable than the ecological, leading to increased participation by social scientists in rangeland research. Now the difficulty level has been raised another few notches as we learn more about the costs of global change and unsustainability of humanity's demands on ecosystems. Greater challenges must be met by greater understanding. Resilience-based management shows promise for helping us meet those challenges, though the next generation surely will have to deal with mistakes we'll make along the way.

Resilience-based management will require improved understanding of social-ecological systems, not only so we better understand the consequences of SES management, but perhaps also so we can work to address wicked problems via scientific and governance institutions that involve rangeland stakeholders in new and more collaborative ways. The conceptual model I have offered suggests how on-the-ground learning can influence both policy and management, even as each is influenced by the ecological consequences of prior policies and management strategies. My hope is it can be used to direct our learning to identify and address the critical linkages between human and natural systems that determine future rangeland sustainability.

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